AIM Wireless

June 20, 2005

Mr. Brett Haan
Mr. Robert Kelly
Mr. Joe Boyer

800 MHz Transition Administrator
c/o Mr. Brett Haan
BearingPoint
1676 International Drive
McLean, VA 22102

Dear Brett, Robert and Joe,

As the start of Rebanding activities come closer and closer, we have seen a growing amount of activity from everyone who is affected by the 800 MHz Rule & Order. In our discussions with the public safety licensees, critical infrastructure companies, consultants, manufacturers and cellular providers, there is a clarification required on a criteria specified in the Rule & Order regarding "comparable facilities" which would help define precisely what activities are required to deliver "comparable facilities".

"All licensees shall be relocated to comparable facilities. Comparable facilities are those that will provide the same level of service as the incumbent's existing facilities, with the transition to the new facilities as transparent to the end user. Specifically, (1) equivalent channel capacity, (2) equivalent signaling capability, baud rate and access time, (3) coextensive geographic coverage, and (4) operating cost." (800 MHz Rule & Order, page 109)

As licensees sit down to negotiate what activities will occur in their re-banding process, it is unclear how a licensee will objectively determine that he has received "comparable facilities" after rebanding. The Transition Administrator's handbook addresses the topic indirectly as part of the acceptance testing process, but is not specific enough to provide guidance.

We have heard varying opinions of what "comparable facilities" means. In the 800 MHz Rebanding Symposiums held by APCO, it was clear that the term was not understood by the participants who asked questions about it. This also occurred in the panel sessions held at the IWCE show in Las Vegas in April.

We feel that the Rule & Order is clear on what "comparable facilities" should entail. The definition of "channel capacity" incorporates the level of interference that exists as a factor which should be measured both before and after rebanding. We have contributed to a "Tech Speak" article in the June, 2005 issue of Mobile Radio Technology, which explains in detail how channel capacity can be objectively measured. A copy of this article has been attached to this letter.

We feel that baseline activities which are done with only a measurement of signal strength ("RSSI" or Received Signal Strength Indicator), will provide the licensee with an inadequate of means to determine if "comparable facilities" has been achieved, and ignores the intent of the 800 MHz Rule & Order and in doing so, compromises its delivery.

This concept has been endorsed by the RF engineering community, as well as the hardware manufacturers. The MA/COM presentation at the Symposium highlights this activity as key to providing an accurate baseline, and the technical advisors of Motorola radio dealers concur.

We would like the Transition Administrator to provide clear and specific guidelines for baseline activities which would lead towards an objective measurement for "comparable facilities".

Sincerely,

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Spectrum Management and Rebanding

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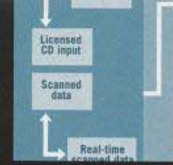

Tech Speak
Getting the most from 800 MHz rebanding
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INFRASTRUCTURE • APPLICATIONS • SECURITY • SAFETY • INTELLIGENCE

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JUNE 2005

MOBILE RADIO TECHNOLOGY
The Official Magazine of IWCE

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E911's FUTURE

A PRIMEDIA Publication

P25 standards battle heats up

European public-safety infrastructure vendor EADS goes head to head with Motorola in the race to provide the platform for the Project 25 Phase 2 standard. Page 24

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BY AHMAD MALKAWI AND MOHAMMED MALKAWI, AIM WIRELESS SOLUTIONS

Spectrum management and rebanding

Quantifying channel capacity ensures comparable facilities and interference mitigation

The first wave of 800 MHz rebanding is scheduled to begin later this month, and spectrum management is a key factor in ensuring the efficient use of a very precious resource. As we have already seen, poor management leads to conflicts and poses serious consequences for public safety and homeland security.

Identifying and measuring interference once was a difficult and costly procedure, as the methodologies had been constrained by a lack of affordable and reliable high-performance tools to deal with a complex problem. But now the bottleneck preventing the accurate identification of external interference has been eliminated, resulting in capabilities that were not available when the FCC's order was written.

This article will describe how to manage spectrum to maximize its potential and how to mitigate interference during and after rebanding. With cost-effective ways to identify and measure interference, rebanding activities can occur in a fiscally responsible manner.

The main impetus for the 800 MHz proceeding is to provide a better spectral environment for public safety and critical infrastructure industries. The order addresses this in three steps:

- It establishes standards for harmful interference now and in the future, and establishes the procedure to report interference, identify who is causing it and who should resolve it.
- It eliminates a major cause of interference by rebanding and provides "comparable facilities" to those that must change frequencies.
- It resolves any remaining problems through interference mitigation.

According to the FCC's definition, comparable facilities "will provide the same level of service as the incumbent's existing facilities, with the transition to the new facilities as transparent as possible to the end user. Specifically, (1) equivalent channel capacity, (2) equivalent signaling capability, baud rate and access time, (3) coextensive geographic coverage and (4) operating cost."

Ensuring that comparable facilities are provided is an enormous engineering challenge. One must consider the hardware configuration, the RF domain and interference. The hardware configuration directly addresses receiver sensitivity, noise figure, thermal noise and the modulation scheme. Various vendors and their mobile radio dealers will perform hardware config-

Continued on page 40

Equation 1

$$\text{CHANNEL CAPACITY} = \text{BW} \times \text{LOG}_2\left[1+\frac{C}{I}\right]$$

Source: AIM Wireless

Table 1

GPS TIME	LATITUDE	LONGITUDE	FREQUENCY	RSSI
0:12:34	41.876217	-87.63465	870.42	-60
0:12:34	41.876217	-87.63465	870.45	-43
0:12:34	41.876217	-87.63465	870.48	-90
0:12:34	41.876217	-87.63465	870.51	-95

Source: AIM Wireless

Channel capacity is the single most important element of defining comparable facilities, and interference is the sole variable that determines whether channel capacity is adequate after rebanding.

uration and handset tuning. It will not be difficult to deliver the required signal strength, baud rate, access time and proper coverage.

Similarly, radio frequency (RF) network engineers can manage RF configuration factors such as effective radiated power and fading (fast fading or long fading) at a reasonable cost. Delivering a sufficient level of RSSI (received signal strength) is a part of the network implementation. Both hardware configuration and RF configuration are controllable factors internal to a network and are not changed in the rebanding process; essentially, they are constants when looking at comparable facilities.

Interference is a more complex issue. There are two types of interference, internal and external. Internal interference consists of co-channel and adjacent-channel interference. These are the easiest to identify and correct. They will surface in the post-rebanding environment only if they existed in the pre-rebanding environment. They can be avoided through proper network design.

External interference includes intermodulation, wideband noise (out-of-band emission) and receiver-spurious interference. External interference occurs whenever the right combinations of frequencies occur under the right conditions in the environment. These are signals that come from some other network.

It is the external interference problem that the FCC's 800 MHz order addresses. External interference is a complex issue, and it will not ago away simply by rebanding. External interference cannot be predicted, nor can it be accounted for in the process of rebanding, without proper analysis. Most important, external interference directly impacts channel capacity, access time, throughput and operating cost.

Channel capacity is the single most important element of defining comparable facilities, and interference is the sole variable that determines whether channel capacity is adequate after rebanding.

By measuring the levels of signal strength and interference, you can quantify channel capacity. Without measuring the level of external interference, you cannot determine what impact it has on comparable facilities. This must be done before and after rebanding, according to standard engineering methodology and best practices.

What is channel capacity? More than 50 years ago, the Bell System Technical Journal published Claude Shannon's article, "A Mathematical Theory of Communications," that provides a mathematical framework for communications engineering and contained the Shannon Theorem (see Equation 1 on page 36).

Channel capacity is a function of three elements: channel bandwidth (BW), carrier power (C) and cumulative noise, i.e., interference (I). Channel capacity increases when interference is decreased. Bandwidth and the signal strength variables are internally controllable elements. External interference, as discussed earlier, is an environment-dependent variable.

To objectively determine that comparable facilities have been provided, we need to execute three conceptually simple steps:

- Measure the channel capacity for each channel before rebanding occurs.
- Measure the channel capacity for the new replacement channel.
- Compare the two values, and it will be obvious whether you received equivalent channel capacity.

Because rebanding will create changes, many new factors will be introduced that may cause external interference. Even channels that are not being rebanded and were operating normally may be affected. The process that follows can provide essential information about interference.

By measuring channel-capacity components before and after rebanding, all possible errors

Table 2

Before rebanding

1	Frequency (MHz)	866.225	
2	Length of route (miles)	1000	
3	Number of segments (300 ft. segments)	17600	
4	Number of segments that do not have signal adequacy	35	
5	Signal adequacy	0.19	%
6	Average signal strength (dBm)	-75	
7	Number of intermodulation interference locations	655	
8	Intermodulation Interference	3.72	%
9	Number of wideband interference locations	755	
10	Wideband interference	4.29	%
11	Number of receiver spurious interference locations	325	
12	Receiver spurious locations	1.85	%
13	Total number of interference locations (deadspots)	1735	
14	% of total interference locations (deadspots)	9.85	%

After rebanding

1	Frequency (MHz)	851.225	
2	Length of route (miles)	1000	
3	Number of segments (300 ft. segments)	17600	
4	Number of segments that do not have signal adequacy	20	
5	Signal adequacy	0.11	%
6	Average signal strength (dBm)	-75	
7	Number of intermodulation interference locations	320	
8	Intermodulation Interference	1.8	%
9	Number of wideband interference locations	410	
10	Wideband interference	2.3	%
11	Number of receiver spurious interference locations	50	
12	Receiver spurious locations	0.28	%
13	Total number of interference locations (deadspots)	780	
14	% of total interference locations (deadspots)	4.43	%

Source: AIM Wireless

(human or otherwise) that may result from the rebanding process can be captured and identified. To measure this, create a baseline of your coverage area.

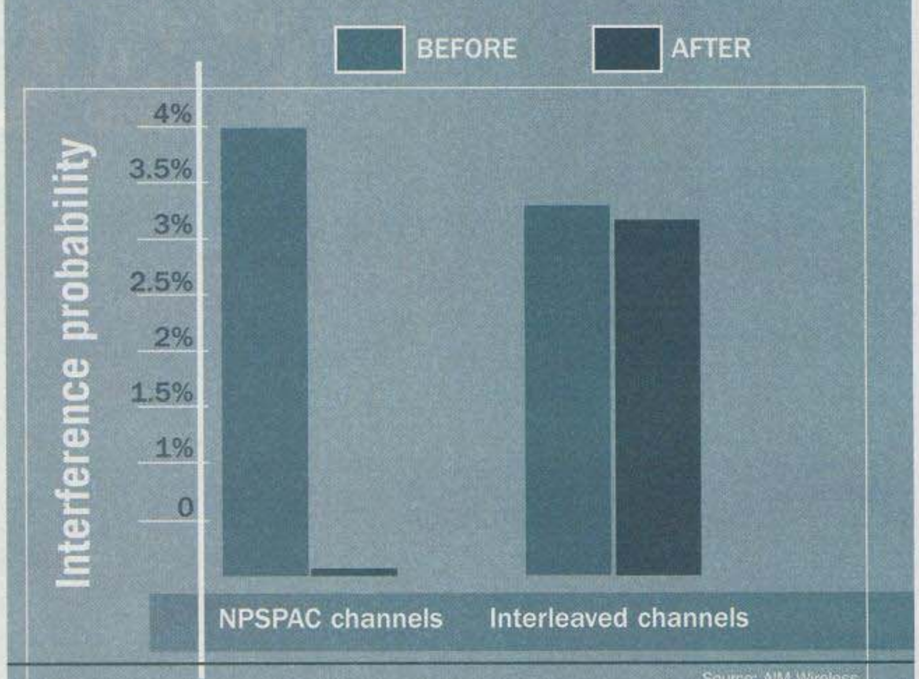
A baseline plan should include a map that denotes the exact routes to be driven. Collect a continuous wave (CW) for the received signal strength indicator (RSSI) for the entire band, from 851 MHz to 895 MHz. This band includes public safety, Nextel, SMR operators, Cellular-A and Cellular-B. Data should include location and the timestamp information. This collection process provides field data with RSSI levels for each frequency, at a specific location identified by latitude and longitude, at a specific time of day (see Table 1 on page 36).

Collect information about the channels to be rebanded, including receiver characteristics (receiver sensitivity, intermodulation rejection and adjacent band rejection) and the exact frequencies being rebanded. Process the scanned data against the rebanded channels and run an interference analysis for intermodulation interference, wideband noise and receiver-spurious noise.

Once this information is processed, produce a comprehensive report for each channel to include RSSI, intermodulation noise, wideband noise, receiver-spurious noise and signal adequacy. Plot the pertinent information on maps of your coverage area. This information constitutes a baseline for comparison after rebanding. The analysis of the data includes the locations and number of dead spots for each channel.

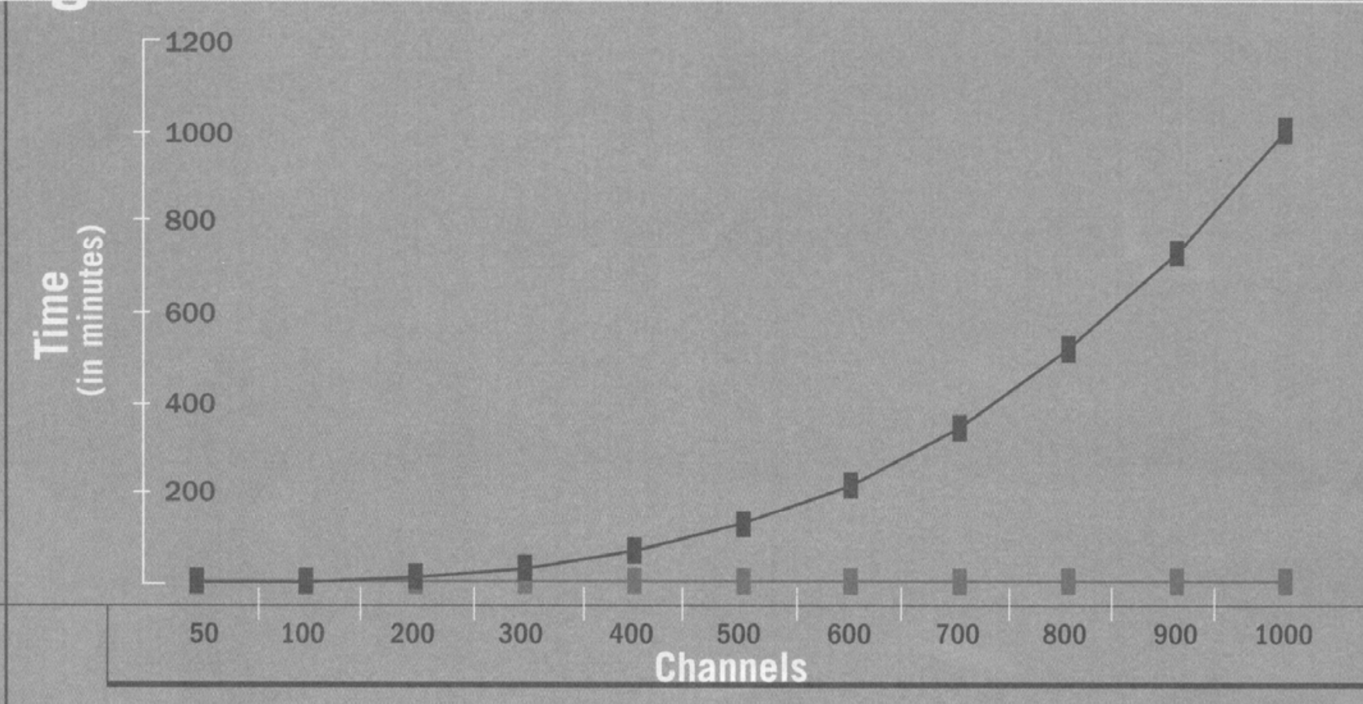
After the actual frequency changes are made to the base station or transmitter, a second drive test should be conducted along the same routes covered in the baseline. The process is repeated, and the results of the second test are compared to the results of the first test (see Table 2 on page 42). The difference in these values will provide a clear picture of the before and after in the environment. These same values should be examined to determine whether comparable facilities have been provided.

Fig. 1



Source: AIM Wireless

Fig. 2



Though the rebanding process provides significant improvement to some parts of the spectrum, such as the NPSPAC channels, many public-safety and critical infrastructure industry (CII) channels will not improve (see Figure 1 on page 44). The fact that some of the public safety and CII channels will still suffer interference is no surprise.

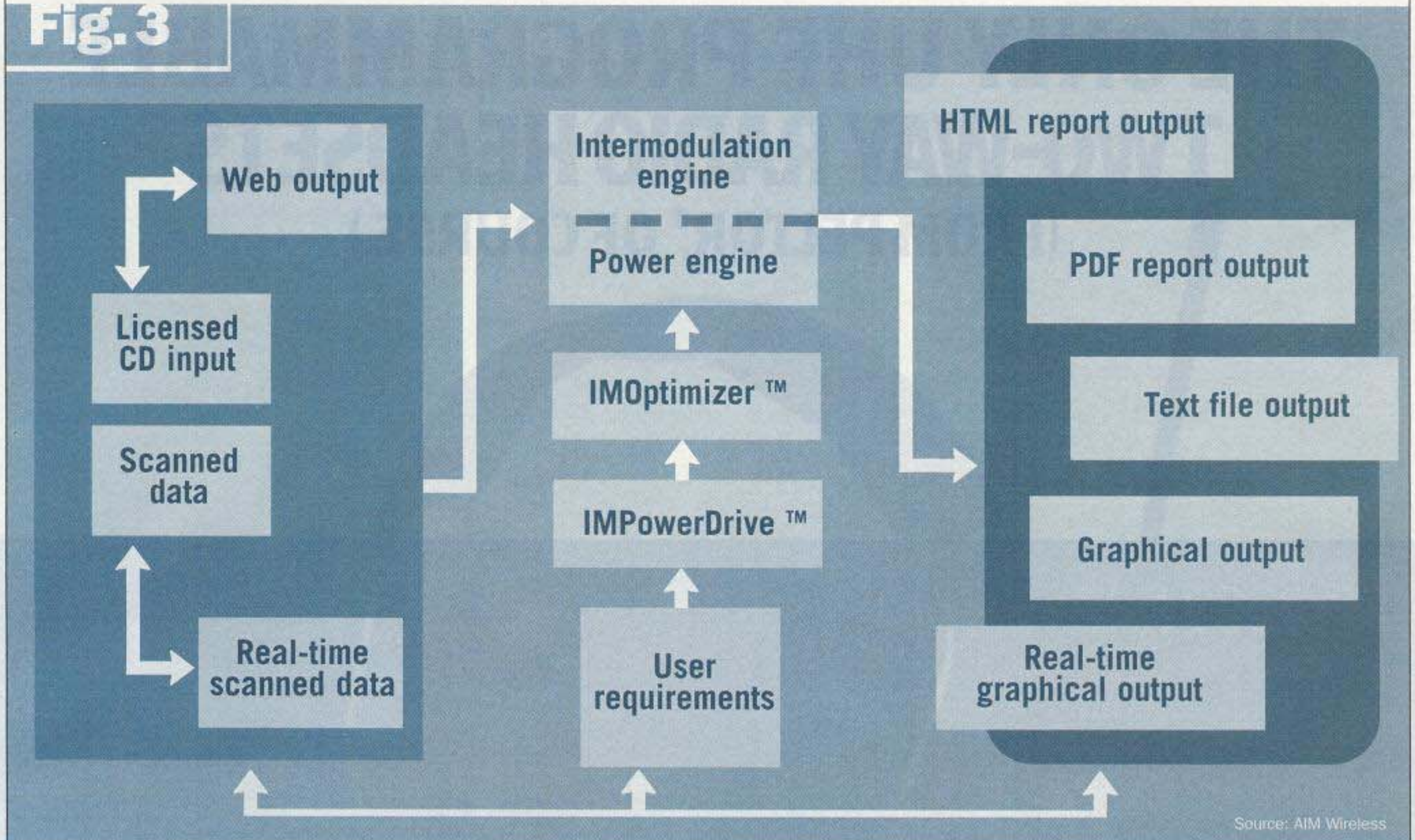
The FCC's 800 MHz order recognizes this: "Based on the extensive and comprehensive record of the proceeding, we are convinced that neither band reconfiguration alone, nor application of 'technical fixes' on a case-by-case basis, would adequately address the interference to 800 MHz public-safety communications systems."

Interference mitigation is achieved by the use of post-processing tools and software. These tools must have the capability of importing and analyzing field data so that the source of the problem can be identified and resolved. The mitigation process can be summarized as follows:

- Collect data.
- Identify the problematic area.
- Import data into a simulation tool.
- Process the data.
- Perform what-if scenarios to identify the problem and find a solution.

Mitigation can be a daunting task, particularly if the number of channels analyzed exceeds 500 channels—a common scenario in an urban environment. Existing tools process an interference study by comparing each channel sequentially (Figure 2). This leads to billions of calculations that must be processed, a process that can use all of a PC's memory and crash the system before completing the task. The simulation tools must have fast processing capabilities to provide timely results. When processing grows from hours into days, it will be impossible to meet the mitigation deadlines imposed in the 800 MHz order. Reducing the amount of data processed by arbitrarily deciding what not to

Fig. 3



process reduces an interference study to guesswork.

The bottleneck in speed is eliminated by a significant advance in how an intermodulation study is processed with AIM Wireless's InterMod60 (Figure 3). Because IMOptimizer and IM PowerDrive are built on the InterMod60 engine, speed is not an issue. The mitigation process can be executed effortlessly, and proven engineering methodologies can be applied.

Input is the fuel to process information—the raw data collected in the field. Data collection is not difficult, but defining the type of data and the collection process is critical to getting the right information. To illustrate this, we will start with the essential data that is needed to run an interference analysis—power and frequency.

By using this methodology, interference can be mitigated before and after rebanding. The same procedures used to create a baseline can then be repeated to objectively determine whether comparable facilities have been delivered to the licensee. The bottlenecks indeed have been eliminated. ■

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